TECHNICAL MEMORANDUMS

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SHORTENING THE LANDING RUN.

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The process of making a landing with an airplane can be divided into two stages, the gently sloping glide by which the landing field is approached and the run along the ground after actually touching. While the length of the second stage governs the actual dimensions of the field, the first part of the process is also of importance, for the necessary degree of openness of approach depends on the nature of the glide. Obviously, if an airplane could be so designed as to settle to the ground vertically, it would not matter how many buildings, trees and telephone wires were located close around the boundaries of the landing space, but if it is necessary to come in on a nearly horizontal path any obstructions become a subject of serious concern. Clear approaches are quite as important as long and level runways.

The problem of landing fields is already a very acute one, and it will become more and more difficult in the future. The desire to reduce to a minimum the time lost in ground transport at the beginning and end of an air journey is leading to attempts to find field sites near the business districts of the cities which they serve, in locations where the cost of real estate is very high. The increasing use of airplanes for sport and touring, and more especially the rapid development of night flying, is mak-

* Taken from Christian Science Monitor

ing it evident that emergency fields will have to be laid out in great numbers within the next few years. If the Air Mail's standard of a landing field every 25 miles is to be applied throughout the continental United States, several thousand sites will have to be selected and marked in addition to all those that already exist. For all these reasons, it is of great importance that the length of the airplane's landing run should be reduced in order that the fields may be made smaller than would otherwise be necessary.

As the landing is divided into two parts, the problem of shortening the distance may be similarly divided. In connection with fields located in rural districts not heavily wooded, the provision of clear approaches is seldom difficult, as buildings are low and overhead wires are few, and the actual length of run after contact is the critical factor in connection with economy of ground. In or near large cities, however, the approaches may be so restricted as to make it necessary to acquire much more property than would be needed for simple taking off and landing, in order that there may be a clear space within which to make a gliding descent, and the slope of the gliding path then becomes a very important matter. In any case, both slope of path and length of roll are important to the pilot who finds himself suddenly obliged to make a forced landing in a small field not regularly intended for aviation purposes and surrounded by trees, a situation which sometimes arises when flying over a thickly wooded country.

Reducing the Speed.

There are a variety of methods for decreasing the length of landing run, ranging from the employment of ordinary design practice in a more or less obvious manner to the use of the most ingenious and elaborate special pieces of equipment. The first step, in every case where landing requirements can be considered as paramount over other factors of performance, is to cut down the landing speed. In general, other things being equal, both the length of run and the amount of damage which the airplane is capable of doing to itself if it hits some obstacle or runs into a ditch soon after touching the ground are proportional to the square of the speed, being very roughly twice as great if the landing speed is 40 miles an hour as they would be if it were 30, and being doubled again by a further rise from 40 miles to 60. The advantage of a low landing speed is then obvious, but unfortunately the attempt to secure it brings other troubles in its train.

In the first place, a reduction of landing speed involves a sacrifice of high speed. The racing airplanes which fly at four miles a minute, land at about 75 miles an hour, and if the landing speed were to be cut down to a mile a minute by the ordinary means the maximum figure would fall off to about 205 miles an hour. Second, the landing speed can only be reduced, generally speaking and leaving such inventions as variable-area and variable-camber wings out of consideration, by increasing the wing area. Twice as much area is required to carry a given weight at a mini-

mum speed of 40 miles an hour as will be needed at 60, and twice as much again at 30. With the customary qualification that other factors in the problem shall be unchanged, then, the length of landing run is inversely proportional to the wing area. Any large increase of wing area of course involves an increase of structural weight, and also makes the housing problem more difficult. The speed can be cut down somewhat, to be sure, by the selection of proper wing sections and by the use of such variable-lift devices as those mentioned above, but any very great change must still involve a direct alteration of the amount of wing surface.

Quick Stops.

The landing speed having been reduced, as far as is wise or practicable, the problem becomes one of stopping as quickly as possible from a given speed without damage to the airplane or danger of injury to its occupants. A very quick stop can be made by a skilled pilot, if an emergency should require it, by nosing the airplane over or by digging one wing-tip into the ground, but those methods are neither dignified nor comfortable, and are likely to involve expensive repairs to the airplane.

The devices which have been tried or suggested for bringing airplanes to a stop quickly may be arranged in two groups, those which act on the air and those which act on the ground. The first group includes all sorts of airbrakes and also reversible propellers, while the second comprises wheel and skid brakes, similar

in theory to the brakes of a road vehicle, and those mechanisms technically known as arresting gears.

An airbrake on an airplane has little in common with an airbrake on a railroad train. One is operated by air, while the other operates on the air. In the airplane the airbrake takes the form of a surface so arranged that its attitude with respect to the flow of air can be changed, with a resultant increase of resistance to forward motion and a consequent shortening of the distance required to slow down. Such a brake is obviously most effective at high speeds, where the air resistance is large.

Airbrakes consisting of panels projecting from the sides of the body have been tried and have proven ineffective. The only type from which any really satisfactory results have been obtained takes the form of a flap on the wing, usually extending the full length of the trailing edge, and so arranged that it can be pulled down by the pilot to a setting nearly at right angles to the forward portion of the wing. The device, very fortunately, has the effect of increasing the lift of the wings as well as increasing the resistance, and consequently serves to lower the landing speed with a given weight and extent of surface as well as to shorten directly the distance required to come to rest from a given speed. It is a very useful adjunct wherever landing performance is considered to be of the first order of importance.

Reversible propellers do not, as the name might be supposed to imply, reverse their direction of operation. The blades of the propeller are made separate from the hub and are so mounted that

they can be turned in their sockets and presented to the air at a new angle. By turning them sufficiently, the direction of the thrust can be reversed, although the sense of the rotation remains always the same. This is the most powerful of all stopping devices, reducing the run along the ground by at least a half, and sometimes by as much as three-quarters. It has, however, one serious defect. Being effective only when the propeller is turning, its usefulness depends on the continued operation of the power plant. The reversible propeller offers no aid in a forced landing, the very condition under which the necessity of getting into a small field is most likely to arise.

Brakes for Ground Use.

The brakes which act on the ground are, as already mentioned, like those of an automobile in theory. Such brakes have not found a very wide use as yet, chiefly because the application of a resisting force at the wheels causes the airplane to tend to nose over, the effect being much the same as that of running suddenly into soft ground or striking a log or rock. In those cases, the airplane would obviously be tripped, as the weight is very nearly balanced about the wheels when running along the ground. It is, therefore, necessary, if brakes are to be used, to incorporate in the landing gear at least one extra wheel or skid placed well out to the front, where it will be effective in checking the nosing over process. Another disadvantage of the wheel brake is that a considerable proportion of the weight of the airplane is still

carried by the wings during the first part of the run, and the pressure against the ground is not large enough for an increase in ground friction to be of great use until much of the original speed has been lost. Despite all this, however, wheel brakes will undoubtedly be used in more instances in the future than at present, especially as it seems likely for reasons quite unconnected with braking, that the provision of an auxiliary wheel under the nose will become more common as time goes on.

Arresting gears are devices planned to shorten the landing run by establishing direct mechanical contact between the airplane and the ground. Although a few types have been designed to be entirely self-contained, the majority require a preliminary installation on the ground. A typical, and very simple, form consists of a drum on which a cable is wound. As the airplane passes overhead a hook trailing below the machine picks up a loop in the end of the cable, and a brake is then applied to the drum to retard its unwinding, and so to check the movement of the airplane, to any extent desired. Obviously such a device has a somewhat restricted usefulness, and up to the present time arresting gears have been used only for landing airplanes on the decks of aircraft carriers. The field of their employment seems unlikely to extend to cover the airplanes of commerce.